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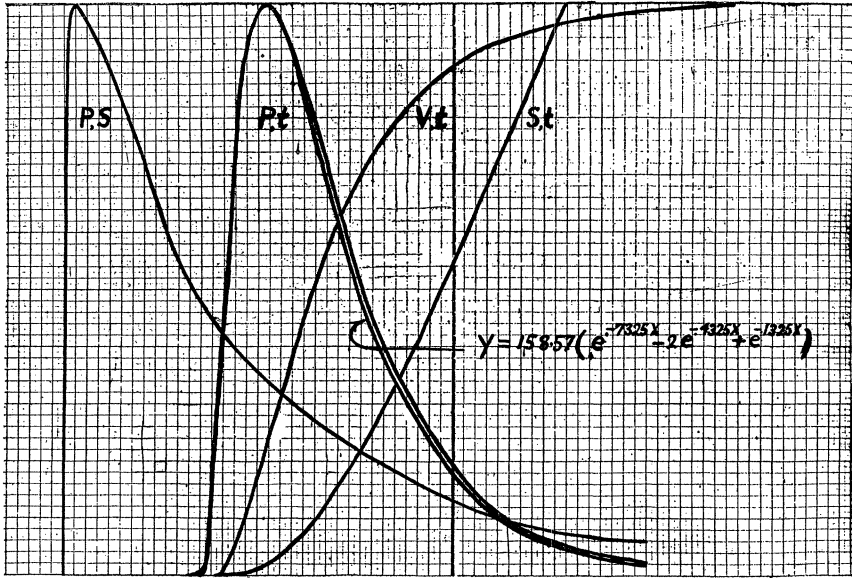


FIG. 4

The emergence of the bullet from the barrel is shown by the interruption of a beam of light thrown upon the film by a separate mirror.

In a subsequent paper the theory of the apparatus and the conclusions that may be obtained from it, including the resistance in the barrel and the variation of specific heats will be described.

### ON THE ANGLE OF REPOSE OF WET SAND

By A. G. WEBSTER

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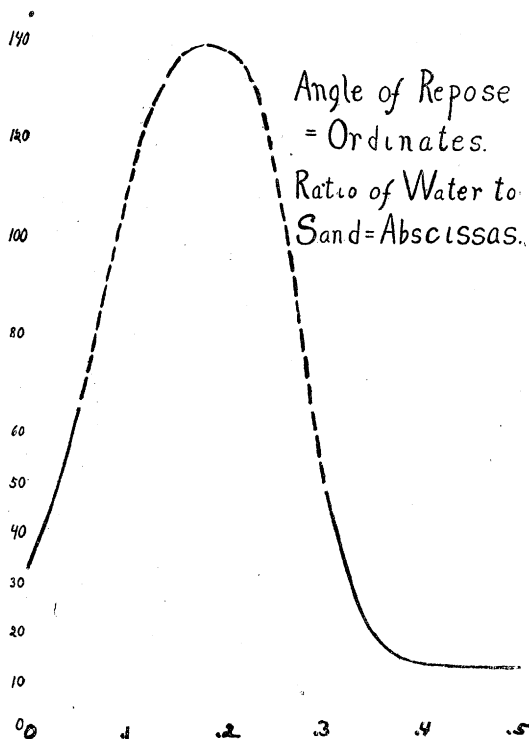
Read before the Academy, April 29, 1919

It is well known that sand, gravel, broken stones, grain, sugar or any pulverulent substance has a definite angle of limiting steepness which is called the angle of repose. In Dr. Breasted's lecture the pile of debris in front of the Temple of Thebes showed such a definite angle. In driving to Washington last week I passed along the Cape Cod Canal and noticed a very definite angle of repose for the sand alongside the Canal. Passing by the beach at Narragansett Pier I measured its slope and found it to be very uniform and about one in fourteen.

\*Contribution from the Ballistic Institute, Clark University, No. 6.

A few years ago a committee of this Academy was sent to Panama to examine into the cause of the Culebra slides. My interest was excited at that time, and a year ago by my being consulted as an expert on the collapse of a house.

A few days ago it occurred to me, having a load of sand on the floor of my ballistic laboratory, to wet it and make an artificial beach. I found that on scraping it up with a board a very definite slope was obtained depending upon the wetness. I therefore requested my assistant Dr. E. A. Harrington to make a few quantitative experiments to determine the angle in terms of the wetness. This is shown in the figure.



Beginning with absolutely dry sand which was weighed in a tray a certain amount of water was added and the whole weighed. At first the added water is quickly absorbed and on account of the work done by the surface tension and the cohesion of the water a certain positive amount of cohesion is obtained by the sand, and it will remain in equilibrium vertically and even overhang. Of course these experiments are not extremely accurate. When a certain degree of wetness is passed the sand then acts like a plastic substance, the degree of plasticity depending upon the relative amounts of water and sand.

The status of the mixture is described in the table.

Professor Harry F. Reid informs me that a continental shelf of the Atlantic Ocean has a very definite slope which is very nearly that obtained for the extremely wet sand in these experiments.

I reserve the mathematical theory for a future paper.

SAND	WATER	ANGLE OF REPOSE	REMARKS
<i>pounds</i>	<i>pounds</i>		
10	0	33°	Dry
10	0.5	65°	Not hard
10	1.0	120°	Not accurate, but large obtuse angle, hard
10	1.5	120°-140°	Not accurate, but large obtuse angle, hard
10	2.0	120°-140°	Not accurate, but large obtuse angle, hard
10	2.5	120°	Not accurate, but large obtuse angle, hard
10	3.0	48°	Fairly hard
10	3.5	19°	All mixes
10	3.75	14.5°	Very slight excess of water
10	4.0	13°	Water not all absorbed
10	5.0	12°	Excess of water

The sand has been meshed by Professor Roys of the Worcester Polytechnic Institute with the following results:

SIZE OF SCREEN	DIAMETER OF OPENING	PER CENT OF SAND WHICH PASSED THROUGH
<i>meshes</i>	<i>inches</i>	
200	0.0029	7.3
100	0.0055	29.55
50	0.011	84.60
30	0.022	99.45
20	0.034	99.85
10	0.073	99.95
4	0.20	100.00

### *PALÆOMASTODON, THE ANCESTOR OF THE LONG-JAWED MASTODONS ONLY*

BY HENRY FAIRFIELD OSBORN

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY

Read before the Academy, April 29, 1919

In 1900<sup>1</sup> the author predicted that the ancestors of the Proboscideans, as well as of the Hyracoidea and some other orders of mammals, would be discovered in Africa. Two years later the members of the British Geological Survey of Egypt discovered in the Oligocene of the Fayûm remains of *Palæo-*